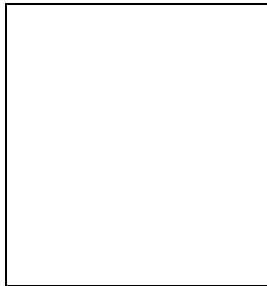# NON SUSY SEARCHES AT THE TEVTATRON

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The CDF and DØ experiments have collected and analyzed about $300\,\mathrm{pb}^{-1}$ of data during the Run II of the Tevatron. Results of searches for new non supersymmetric particles based on these datasets will be presented.

## 1 Introduction

Although supersymmetry (SUSY) is one of the most popular models of physics beyond the Standard Model, alternative models have been proposed. Models of additional spatial dimensions are actively developed. Other models include technicolor, compositeness and models with additional Z and/or W like bosons.

The Tevatron is currently at the high energy frontier with $1.96\,\mathrm{TeV}$ center-of-mass energy and thus is one of the major facilities for the discovery of new particles. Searches for new particles at the Tevatron use one or several tool(s) to control the huge QCD background : presence of electrons and/or muons, missing transverse energy (MET), identified heavy flavor jet, identified tau decays, etc. . .

In the following, the results of searches for new non SUSY particles will be briefly described, more details can be found elsewhere [1,2].

## 2 Leptonic final states

Unless explicitly mentioned, the leptonic final states only cover the final states with electrons and/or muons.
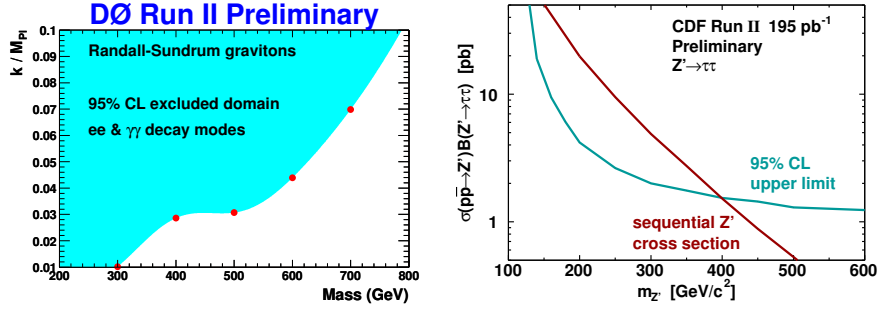
(a) Excluded domain in the coupling versus mass of the first excitation of the graviton in the Randall-Sundrum model of extra dimensions based on a di-electron and di-photon sample of $\sim 200\,\mathrm{pb}^{-1}$ of DØ data.

(b) Cross-section times branching ratio for a sequential Z' boson decaying to taus with the upper limit derived from $195\,\mathrm{pb}^{-1}$ of CDF data.

Figure 1: Di-lepton results

## 2.1   Dilepton final states

The di-electron and di-muon samples have low background contamination and a well understood Drell-Yan contribution. They form a good sample for searching for new particles in direct search (particles decaying to di-leptons like extra gauge bosons, technicolor particles, Kalusa-Klein excitations in some extra dimensions models, ... ) or in indirect effects in di-lepton production (compositeness, extra dimension models, ... ).

New physics would often be visible only in the high end of the invariant mass spectrum. Since electrons are measured in calorimeters, the di-electron sample benefit from a good mass and transverse momentum (pT) resolution, and easy triggering conditions. On the other hand, one has to control and understand the contamination from QCD events where jets are mis-identified as electrons. This has to be measured from real data as the simulation is not reliable enough at that level of precision. CDF and DØ have selected samples based on approximately $200\,\mathrm{pb}^{-1}$, selecting events with two electrons with pT in excess of $25\,\mathrm{GeV}/c$, one of which being required to be in the central part of the calorimeter. Similarly, di-photon samples are selected. The QCD background is less important in the isolated di-muon sample, but special care has to be taken to understand and reduce the background from cosmic rays. The CDF sample is based on $\sim 200\,\mathrm{pb}^{-1}$ and requires two muons with pT of excess of $20\,\mathrm{GeV}/c$, one with $|\eta| < 1.0$ and one with $|\eta| < 1.5$. The DØ sample is based on $\sim 250\,\mathrm{pb}^{-1}$ and requires two muons with pT of excess of $15\,\mathrm{GeV}/c$. A good agreement is found between the data and the prediction from Standard Model MC complemented by background estimates from real data (QCD and cosmics).

Since no significant deviation from the Standard Model has been observed, the results are interpreted as limits within various models of new physics. A few selected results are shown here, additional results can be found elsewhere [1,2]. Figure 1(a) show the excluded domain in the coupling versus mass of the first excitation of the graviton in the Randall-Sundrum model of extra dimensions from DØ. An interpretation of CDF results combining the electron and muons channels allow to set a limit on the mass of an additional sequential Z boson at $815\,\mathrm{GeV}/c^2$. This search has been extended to the tau channel as can be seen in figure 1(b).

**Search for a Z from long lived parents**

In some models, Z bosons can be produced in the decays of long lived particles. CDF looks for such a striking signature in a di-muon sample from $163\,\mathrm{pb}^{-1}$ of data. In addition to selecting the Z mass region, additional criteria are used to ensure a good reconstruction of the Z vertex, namely tight track quality criteria and the requirement of a minimum acoplanarity between the two muons. Two independent analyses are then applied : in the first, a tight cut of $0.1\,\mathrm{cm}$ is applied on the transverse decay length $L_{xy}$ of the di-muon system (with 2 events observed for $0.72 \pm 0.27$ expected) and, in the second, a loose $L_{xy} > 0.03\,\mathrm{cm}$ cut is applied while the di-muon system is required to have a $\mathrm{pT} > 30\,\mathrm{GeV}/c$ (with 3 events observed and $1.1 \pm 0.8$ expected). The results are interpreted in the model of a sequential b' quark lighter than the top quark in figure 2.
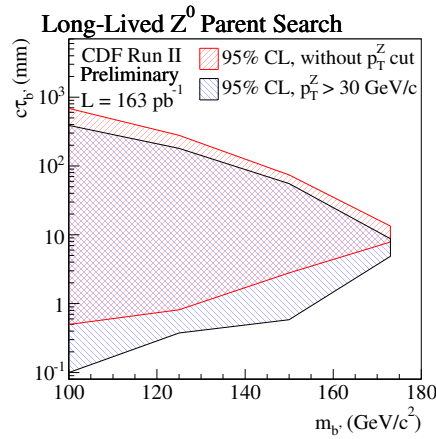


Figure 2: Limits in the decay length versus b' mass from CDF.

*2.2   Search for a W'*

The di-lepton samples allowed to search for a new Z-like gauge boson. CDF has extended that search to that of a W-like boson (W') in the electron channel. Events with one isolated electron with $\mathrm{pT} > 25\,\mathrm{GeV}/c$, $\mathrm{MET} > 25\,\mathrm{GeV}$ and $0.4 < \mathrm{pT/MET} < 2.5$ (to reject QCD background) are selected. Assuming Standard Model couplings strength, the analysis result in a limit on the W' mass of $842\,\mathrm{GeV}/c^2$ using $205\,\mathrm{pb}^{-1}$ of data, with systematics dominated by the PDF uncertainties and the understanding of the electron energy scale.

## 3   Lepton plus jets final states : leptoquarks

Leptoquarks arise in various models beyond the Standard Model. They decay to a lepton and a quark or a neutrino and a quark. First generation leptoquarks are supposed to decay only to electron and/or electron neutrino while second generation leptoquark would decay only to muons and/or muon neutrinos. The branching fraction to the charged lepton is model dependent, so the searches are designed to cover all three final states : di-lepton and jets; lepton, MET and jets and jets plus MET.

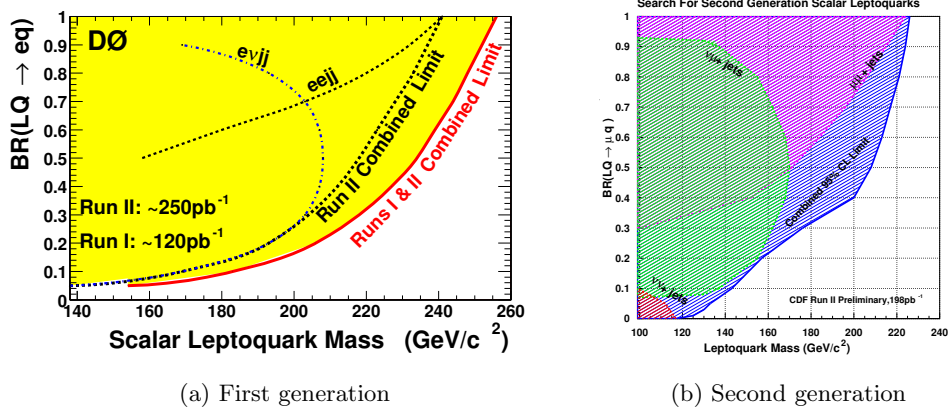Limits on first and second generation scalar leptoquarks from DØ and CDF are shown in figure 3.

(a) First generation



(b) Second generation

Figure 3: Limit on the scalar leptoquark mass as a function of the branching ratio to lepton+quark.



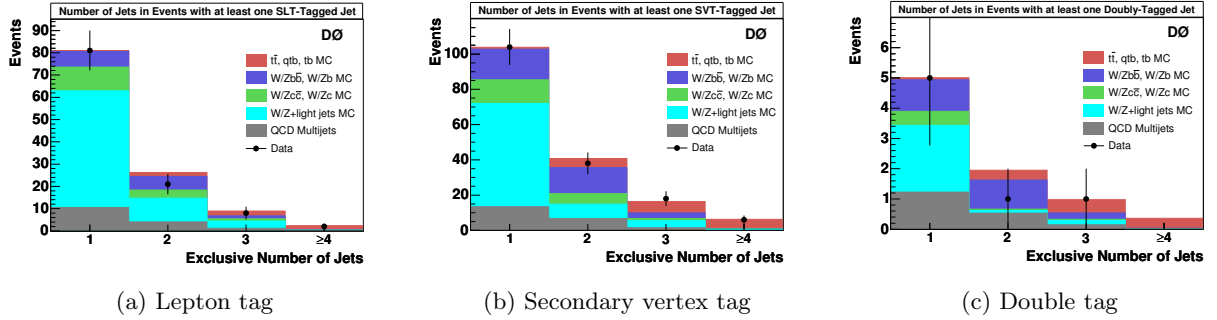(a) Lepton tag



(b) Secondary vertex tag



(c) Double tag

Figure 4: Number of jets tagged by one or both of the b-tagging algorithms.

## 4    Anomalous W plus heavy flavor production

Studying the associated production of a W with heavy flavor jet(s) is important as it constitutes a background to e.g. top and Higgs selections. Conversely, any deviation from Standard Model expectations would be a hint of new physics. DØ has looked for anomalous production of heavy flavor jet in association with a W in the electron and muons channels using $\sim 150\,\mathrm{pb}^{-1}$ of data. The events are required to have one electron (resp. one muon) with pT$> 20\,\mathrm{GeV}/c$ and $|\eta| < 1.1$ (resp. $|\eta| < 1.6$), with MET$> 20\,GeV$ and not aligned to the lepton. The transverse mass of the lepton and MET is required to be between $40\,\mathrm{GeV}/c^2$ and $120\,\mathrm{GeV}/c^2$. Jets are potentially identified as b-jets using two independent algorithms, one based on the presence of a muon in or nearby the jet and the other on the reconstruction of secondary vertices. As can be seen in figure 4, a good agreement is found on the number of tagged jets between data and expectation for MC events. As no excess is seen, limits are set on the production cross-section of a $Wb\bar{b}$ type signal at $26.3\,\mathrm{pb}$ and on a top-like signal at $14.9\,\mathrm{pb}$.

## References

1. CDF collaboration, http://www-cdf.fnal.gov/physics/exotic/exotic.html
2. DØ collaboration, http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm